Drill and Didactic Teaching Work Best

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While drill and didactic teaching are now second nature to me, there are many who consider such traditional methods to be the preserve of old, crusty, fuddy-duddy, elbow-patched, pullover-wearing public school teachers who really might drill and kill motivation. In fact, drill can thrill, and didactic teaching can result in children who are impassioned by your subject. In this chapter, I shall suggest ways to implement drill and didactic teaching in the classroom and argue why it works best by outlining and deconstructing four arguments to the contrary. As a Science teacher, I am going to give particular emphasis on drill and didactic teaching in Science.

We need to didactically teach knowledge and embed it into pupils' long-term memories through drill. Didactic teaching is the pedagogy of imparting immutable facts. At Michaela, we embrace the pedagogical view of the teacher as the fountain of knowledge, which is why pupils sit in rows facing the teacher. There is no guesswork at Michaela. Repeated practice of using this knowledge enables pupils to achieve automaticity. This practice is known as drill. Allow me to outline how drill and didactic teaching work best to teach the concept of density, or indeed any other concept, below.

Prior to this lesson, pupils would have spent a fortnight learning about the fundamentals of 'matter.' They would have learned that atoms are the tiny building blocks of all matter, as well as about sub-atomic particles. Pupils would have learnt that matter must have volume and mass as well as their definitions, by heart, through drill. When automaticity in more basic content is achieved, pupils can move more quickly towards more complex content. Pupils would be able to identify volume and mass as physical properties of matter and contrast physical properties with chemical properties. The teacher would have instructed pupils on procedures to calculate volume and pupils would have practiced these through increasingly challenging drills. Having mastered this, pupils would have learned how to calculate the volume of an irregularly shaped object by the displacement of a known volume of liquid and would have then carried out a practical doing so. Pupils would already have thorough knowledge of this practical method and the story of Archimedes, the scientist who discovered this method.

Whole-class recap

To begin the lesson, there is a whole-class recap on definitions memorised in the previous lesson. The teacher expects every member of the class to contribute. Drilling pupils on definitions produces learners who are proficient at the basic but fundamental subject foundations.

Teacher: State the two things that matter must have. One, two, three...

Whole class: Volume and mass!

Teacher: Identify the name given to the amount of space that matter takes up in a three-dimensional object. One, two, three...

Whole class: Volume!

Teacher: State whether mass is a chemical or physical property of matter. One, two, three...

Whole class: Physical property!

Teacher: State the person who discovered how to calculate volume by displacement. One, two, three...

Whole class: Archimedes!

Teacher: For a regular cuboid object, volume equals... One, two, three...

Whole class: Length x width x depth!

Teacher: State how many grams are in one kilogram. One, two, three...

Whole class: 1000!

Teacher: State how many millilitres are in one cubic centimetre. One, two, three...

Whole class: One!

The teacher cold calls pupils, asking them to recite the definitions learned in previous lessons.

Teacher: Mischa, define mass.

Mischa: The amount of space that matter takes up in an object?

Teacher: Almost! Said, can you help Mischa out?

Said: Instead of just object, we're meant to say that it's a three-dimensional object. Mass is the amount of space that matter takes up in a three-dimensional object.

Teacher: What do you think, Sam?

Sam: Miss, I agree.

Teacher: Can you articulate what you agree with, Sam?

Sam: That mass is the amount of space that matter takes up in a three-dimensional object.

Teacher: Excellent use of full sentences, Sam! The reason we are to refer to three-dimensional objects is because objects in the real world have three dimensions that are length, width and depth.

Individual recap

Pupils recap individually by answering questions in their exercise books, enabling the teacher to assess their own understanding of volume and mass. The teacher should circulate the classroom during individual recap to gather data on which pupils are making mistakes, and to assist the weakest with trouble spots. As the time for recap comes to an end, the teacher will choose pupils to contribute answers, whilst other pupils self-mark their work with a green pen.

1. State the common units of measurement for the volume of solids.
2. State the two things that matter must have.
3. Complete the formula used to calculate the volume of a regular cuboid object.
4. State the common units of measurement mass.
5. Define volume.
6. Define mass.

Whole-class reading

The teacher introduces the concept of density by nominating pupils to read sections of the textbook aloud. The teacher stops at natural points in the reading to clarify, restate or expand upon points raised in the text. The whole class chants key facts or procedures in order to aid memorisation. The teacher cold calls pupils, asking them simple comprehension questions, to ensure understanding and maintain focus.

Yasmine: The sixth physical property that we use to describe matter in a solid, liquid or gas state is the density of matter.

Teacher: Last lesson, we learned about five of the physical properties used to describe matter in a solid, liquid or gas state: compressibility, intermolecular forces between atoms or molecules, movement of atoms or molecules, volume and shape. State *all* six physical properties, Abdi.

Abdi: Compressibility, intermolecular forces, movement, volume, shape and density.

Teacher: Thank you, Abdi. Leah, continue reading.

Leah: Density is the mass of a substance per given volume.

Teacher: I say, you say: density is the mass of a substance per given volume...

Whole class: Density is the mass of a substance per given volume!

Teacher: Density is the mass of a substance per given volume. One, two, three...

Whole class: Density is the mass of a substance per given volume!

eacher: Define density, Mischa.

Mischa: Density is the mass of a substance per given volume.

eacher: Fantastic listening, Mischa. Joseph, take over from Mischa.

oseph: This 'given' volume is most often one cubic centimeter, or one millilitre.

eacher: So, density tells us the mass of a substance per given volume, which usually one cubic centimetre. Density is usually the mass of a substance per hat given volume? One, two, three...

hole class: One cubic centimetre!

eacher: I say, you say: density is the mass of a substance per given volume, sually one cubic centimetre. One, two, three...

hole class: Density is the mass of a substance per given volume, usually one ubic centimetre!

acher: Next, Ashley.

shley: So, when we talk about density, we are talking about the mass of one bic centimetre or one millilitre of a substance. The formula for calculating nsity is: density = mass / volume.

acher: To calculate density, density equals what? Kevin!

vin: Density equals mass divided by volume, miss.

acher: Thank you, Kevin. Aaliyah, continue reading.

liyah: The most obvious way of finding the density of a material is to easure its volume and mass. The unit of volume can be cubic metres or cubic ntimetres for matter in a solid state and litres or millilitres for matter in a uid state. The unit of mass can be kilograms or grams. The most common it of density is grams per cubic centimetre.

Teacher: Thank you, Aaliyah. I say, you say: density is measured in grams per cubic centimetre. One, two, three...

Whole class: Density is measured in grams per cubic centimetre!

Teacher: So, density is the mass of a substance per given volume, usually one cubic centimetre. The common unit of measurement for density is grams per cubic centimetre. Alexandra, continue reading.

Alexandra: This means that when we find out the density of a substance, we are finding out how many grams are in one cubic centre of that substance. It might be surprising to learn that the mass of one cubic centimetre of mercury is not the same as the mass of one cubic centimetre of gold, nor is it the same as the mass of one cubic centimetre of carbon dioxide.

Teacher: Look closely at Figure 3.36 to check out the masses of one cubic centimetre of different substances. Identify the substance with the highest density. Summer!

Summer: The substance with the highest density is gold, miss.

Teacher: Thank you, Summer.

Individual drill

These six short drill questions assess pupil understanding of what has been read and taught. If pupils finish, they are expected to memorise one or two definitions related to the lesson using the Michaela method, self-quizzing. The teacher will choose pupils to contribute answers, whilst other pupils self-mark their work with a green pen. An example of these drill questions can be:

1. State the unit(s) of volume for solid matter.
2. State the unit(s) of volume for liquid matter.
3. State the unit(s) of mass.
4. Identify the unit of density.
5. State the formula for calculating density.
6. Define density.
7. Self-quiz on density.

Whole-class instruction

The whole class looks at examples together. There are a number of ways to do this, such as instructing pupils to look over the examples in silence, modelling examples on the visualiser or board, instructing pupils to whisper an explanation of the example to their partner or nominating a pupil to read through the example.

Teacher: Imagine that you have cubes of solid gold, solid magnesium, liquid water, liquid mercury and carbon dioxide gas all held in an invisible cuboid container. Imagine that next to that you have a ruler and some scales. The length, width and height of each of these cubes equates to one centimetre. Therefore, all of the cubes have a volume of one cubic centimetre. However, put them on the scales, and you will find out that all of the five different substances have different masses. The mass of one cubic centimetre of gold is 19.7 grams, magnesium is 1.7 grams, water is one gram, mercury is 7.6 grams and carbon dioxide is 0.002 grams. This is because the atoms, molecules or compounds that make up some of those substances are closer together than the atoms, molecules or compounds that make up some of the other substances. This is density. Density is the mass of a given volume of a substance. The molecules or compounds are also composed of different atoms that have different masses.

The teacher can use the board and work through the procedure for calculating density.

Individual drill

Having explained the concept, the remainder of lesson time can be used to drill pupils to ensure that they can effectively complete taught procedures.

1. The mass of a substance is 30 g and its volume is 120 cm^3. Calculate the density of the substance.
2. The volume of a substance is 200 cm^3 and its density is 1.5 g/cm^3. Calculate the mass of the substance.
3. The mass of a substance is 1 kg and its volume is 450 cm^3. Calculate the density of the substance.
4. The mass of a substance is 45 g and its density is 0.5 g/cm^3. Calculate the volume of the substance.

[Another eight questions on calculating density.]

13. Define the term 'density.'
14. Identify the substance from questions 1-12 with the highest density.
15. Identify the substance in Figure 3.36 with the lowest density.
16. Self-quiz on 'density.'

Many educationalists, both past and present, have criticised the value of didactic teaching and of drill. Educationalists such as Dewey, Piaget and

Vygotsky believed that if teachers crafted learning environments carefully enough, they could pique the curiosity of children to the point that the children taught themselves. Rather than the teacher transmitting knowledge to children, this child-centred approach enabled children to pursue their own inclinations and interests. This shift in the view of the teacher as the fountain of knowledge to a facilitator of learning began in the early 1960s and is known as progressivism. When proponents of progressive education refer to drill and didactic teaching, they often use pejorative terms such as 'drill and kill' and 'rote learning.' It is often claimed that drill and didactic teaching take the joy out of learning, and that such methods are ineffective.

Progressive argument 1: Teachers should let pupils discover

The phrase 'think like scientists' is regularly mentioned. In a Science laboratory, progressive approaches would require pupils to discuss and hypothesise the expected outcome of an experiment, even if their underpinning scientific knowledge is shaky or relatively new, and then carry out the experiment to discover for themselves. A few pupils will be able understand through discovery, albeit with very basic understandings. The majority of pupils either fail to discover or develop misconceptions that are difficult to resolve, or worse, identify. Experts need to acknowledge that even the greatest scientists did not think like experts when they started out. They thought like novices. As Daniel Willingham explains, history has taught us that the most important scientific discoveries were made as a result of accumulating knowledge and experience over years.

Imagine the 30-year-old puzzle of the Rubik's cube. It would be every eager child's (and adult's!) dream to discover the secrets of solving the cube. However, only a tiny number are able to work it out for themselves, with the majority becoming bored and disenchanted within a few minutes, as my colleague Jessica Lund discovered. Then another colleague, who herself had been taught the methods to solve the cube, taught Jessica explicitly the algorithm involved. Jessica took the Rubik's cube to her form class and within days there were 20 children engrossed as they had been given the necessary information needed to complete the cube. There is a lesson to be learned here: give learners the necessary information and opportunities to practise, and their enthusiasm won't go to waste. Hattie's 2009 statistical meta-analyses show that minimally guided constructivism or discovery-based learning does not work best in improving pupil achievement. Much of the time, discovery fails to materialise, but with sufficient drill and didactic teaching, enduring success over time can be guaranteed.